PATENT SPECIFICATION 617,817

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Index at acceptance:—**Classes 9(i),** C(1a2: 5d); **83(iv),** O1a(4: 7); **and 92(ii),** B8e.

COMPLETE SPECIFICATION

Improvements in or relating to Gun Perforators particularly for Perforating Well Casings

We, BYRON JACKSON Co., a corporation organised under the laws of the State of Delaware, United States of America, of 2301, East Vernon Avenue, City of Vernon, State of California, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to gun perforators and has particular application to gun perforators for well casings although it may also be useful in other types of gun perforators.

A general object of the invention is to provide a simpler gun structure by changing the usual detonating elements for exploding the powder charge.

A further object of the invention is to provide a gun perforator wherein a concussion responsive propulsive charge is detonated by the concussion from a detonating charge which is detonated in front of the projectile, and which concussion is transmitted by the projectile to the propulsive charge.

In accordance with the present invention, the improved gun perforator, particularly for well casings, comprises a gun body defining a gun bore, a projectile in said gun bore, a concussion-responsive propelling explosive charge in said gun bore rearwardly of said projectile, and concussion - generating explosive means in front of said projectile, which on explosion drives the projectile rearwardly in the gun bore, thereby exploding the propelling charge.

The present invention also provides a gun perforator, particularly for well casings, comprising an elongated gun body defining a number of laterally directed gun bores, a projectile in each of said gun bores, a concussion-responsive propelling explosive charge in each gun bore behind the projectile, and concussion-generating explosive means in front of each projectile, which on explosion drives the projectile rearwardly in the gun bore, thereby exploding the propelling charge.

Briefly, to detonate the powder charge in a gun perforator in accordance with the invention, the projectile is forced back against the powder with sufficient violence to explode it. The forcing back of the projectile is preferably accomplished by firing a relatively small amount of relatively powerful, fast-acting explosive in front of the projectile. In a gun perforator having a number of firing chambers in a single body, the igniting explosive may be in the form of a continuous fuze extending across the muzzles of all the chambers.

A full understanding of the invention may be had from the following detailed description read in connection with the drawings in which:—

Fig. 1 is a vertical section through the upper part of a well casing perforating gun incorporating the invention.

Fig. 2 is a cross section taken in the plane II—II of Fig. 1;

Fig. 3 is a cross section taken in the plane III—III of Fig. 1;

Fig. 4 is a cross section showing an alternative shape of gun body to that shown in Fig. 3;

Fig. 5 is a fragmentary section showing a modification of the gun structure shown in Fig. 1; this view being also a section through one of the gun bores of Fig. 6;

Fig. 6 is a detail side elevation showing a modification of the arrangement of Fig. 1; and

Figs. 7, 8 and 9 are views similar to Fig. 5 showing alternative arrangements.

Referring first to Figs. 1 and 2, the gun therein disclosed comprises a solid

body 10 adapted to be secured at its upper end in any desired manner to a cable by which it may be lowered into a well casing to be perforated. The cable may contain an insulated electrical conductor 12 which is brought out of the lower end of the cable within an adapter 11 and connected by means of a banana plug 12a on the adapter and a jack 12b in the body 10 to another conductor 14 leading to an electrical fuze 15 which may be of standard type and functions to ignite one end of a fuze-like explosive element 16 which extends from the electrical fuze 15 longitudinally of the body 10 in a groove 17 provided for it.

As shown, the electrical fuze 15 is sealed by cement 15c within a fuze tube 15a which is held in a pocket provided therefor in the body 10 by a screw 15b so that the fuze is protected against wetting and physical damage during handling of the gun and lowering it into a well.

The groove 17 extends across the muzzles of a number of gun bores 19 which, in the particular form of gun shown in Fig. 1, are all positioned in the same vertical plane and are vertically spaced uniformly from each other, having no opening whatsoever other than that at the muzzle end which is located in each case at the grooves 17.

There is shown in each gun bore 19 a powder charge 20 and a projectile or bullet 21, the powder charge being preferably separated from the bullet by a mass of sealing material 22 which prevents entry of water or other fluid past the bullet 21. The sealing material 22 may be a plastic water-proof preparation such as rubber or plastic sealing compound which is compressed between the powder charge and the bullet when the latter is placed in position.

The bullet is preferably fitted to the gun bore with such tightness that it retains itself in place by friction, although in some instances it may be desirable to employ loosely fitting bullets and maintain them in place with wadding or a plastic material placed in front of the bullet.

As shown in Fig. 1, the fuze-like explosive element 16 is looped into the muzzle end of each gun bore as indicated at 23. In some instances the resistance of the element 16 to bending may offer sufficient frictional engagement to retain the loops 23. However, to insure that they remain in place, each loop may be held in its associated gun bore by a flat wedge 25 of wood or thermosetting plastic material, which wedge is driven into the gun bore until its outer end is flush with the outer surface of the gun.

The explosive element 16, although being similar to a fuze in that it consists of an outer flexible, fluid-proof casing containing combustible material, differs from a conventional fuze in that the combustible material employed consists of an explosive having very fast burning characteristics so that when set off by the electrical fuze 15, the whole element 16 explodes practically instantaneously with terrific force. This force acting against the bullets 21 drives them back against their powder charges 20 with sufficient impact to explode the charges. Furthermore, although the powder charges 20 may be of conventional types employed in gun perforators, they seem to explode with more force when set off in the way described than when they are ignited with the usual firing elements. Hence, it appears that when exploded in accordance with the present invention, ordinary powders detonate rather than exploding in the usual manner.

It may not be necessary in all instances to loop the element 23 into the muzzle of each gun bore as shown in Fig. 1. In some instances the force of the explosion of the element 16 is sufficient to detonate the powder 20 if the element is simply extended straight across the muzzle. The exact amount or length of the element that must be positioned in or adjacent to the muzzle, is dependent upon the explosive properties of the element, the length of the gun bore, the tightness with which the bullet is fitted in the gun bore, the quantity and nature of the sealing member 22 and the character of the powder charge 20, all of which factors may be varied to suit particular circumstances.

Various commercial explosive elements can be employed as the element 16, typical examples of which are sold under the trade names of "Primacord," "Mericalcord" and "Cordeau." An explosive that may be used as the core of the element 16 is penta erithritol tetranitrate, the speed of propagation of the wave front of which is believed to be about 21,000 feet per second.

A great advantage of the construction described is the simplicity of the gun structure itself. The body 10 may be forged from a single billet of tool steel and the groove 17 and the gun bores 19 formed by simple conventional machining operations. It is to be particularly observed that no wires, threads and seals are required other than the seal necessary to protect the powder charge from fluids that may be present.

When the gun barrels or bores are all positioned in a single vertical plane, the

cross section of the gun body need not necessarily be circular as shown in Fig. 3. Instead it might be rectangular as shown at 10a in Fig. 4, in which case some material can be saved and a turning operation eliminated. The elimination of as much machining work as possible is desirable because the gun body must usually be made of high quality tool steel which is expensive, in addition to being relatively difficult to machine. High quality steel is desirable, if not essential, in order to secure the necessary strength to withstand the violent explosive forces that are employed and to reduce the wear of the gun bores from repeated use. Special steel known in the trade as " Omega " steel has been found satisfactory, although various other steels may be equally suitable.

It may be desirable in some instances to distribute the different gun bores 19 in the cylindrical body of Fig. 1 so that different bullets are shot in different directions. There is shown in Fig. 6 a construction in which the gun bores are arranged with their muzzles in a helical path extending around a cylindrical body 10b, in which case the groove 17b containing the detonating element is in the form of a helix extending across the gun muzzles.

There is also shown in the detail view of Fig. 5 a different manner of providing additional quantities of the detonating element in the muzzle of each gun bore. Thus in the construction of Fig. 5, the main element 16c is extended straight across the gun muzzles but a short piece 17 of the explosive element is looped around the element 16c at each gun bore and the ends extended into the gun bore. The friction of the elements 27 against the walls of the gun bores is relied upon to retain them in position.

In the arrangement of Fig. 7 additional explosive force is obtained by placing a capsule 30 of fluid resistant, yieldable material within the gun bore in front of the bullet 21d, the capsule containing a suitable explosive.

In any of the arrangements shown in the drawings, the force applied to the bullet may be increased by applying a gob of quick drying cement over each muzzle as the final operation. The cement acts as stemming to increase the force of the explosion in the opposite direction, that is, into the muzzle.

An alternative arrangement of the gun barrels to those disclosed in Figs. 1 and 6 is to arrange them all in a single vertical plane but have successive barrels pointing in opposite directions so that the recoil forces are more or less balanced. Such a gun may be of circular cross section as shown in Fig. 4. Detonation may be effected by employing two separate elements 16 in two grooves corresponding to the grooves 17 positioned on opposite sides of the body, or a single explosive element positioned in a helical groove extending across all the gun muzzles as shown in Fig. 6 may be employed.

Although the adapter 11 may be secured to the body 10 in various manners, a particularly effective way is to employ a snap ring 31 which is seated in an external groove 33 of the adapter and which normally expands to completely fill a shallow groove 32 in the body 10. The ends of the ring are bent outwardly into a recess 34 in the body as seen in Fig. 2, and by squeezing these ends of the ring together, the ring can be contracted to be completely within the groove 33 to permit release of the adapter from the body 10. A rubber washer 47 is provided between the lower end of the adapter and the body to reduce leakage of current from the banana contact 12a and jack 12b to the body 10 in the presence of conductive fluids.

The use of the removable fuze tube 15a permits rapid reloading of the gun in the field, since a number of extra tubes having fuzes cemented therein may be kept on hand. Each fuze 15 may be connected to its tube by a soldered lead 35 to complete the circuit to earth.

The explosive core 16 may, in some instances, advantageously consist of metallic tubing such as lead or copper, filled, with an explosive having the necessary characteristics. The metal will resist the action of the fluids present in some wells better than the impregnated fabric coverings commonly used on such fuze structures.

If desired, separate gun barrels may be employed as shown in Fig. 8 in which barrels 36 are freely fitted in sockets 37 provided therefor in the body 10e and detachably retained in place by snap rings 38 functioning in the same manner as the snap ring 31 of the adapter 11. The use of the separate gun barrels facilitates reloading of the gun in the field since a supply of loaded barrels may be carried along.

There is disclosed in Fig. 9, an alternative expedient for driving the bullet back to explode the main charge. In this embodiment, a charge of explosive 40 is placed in the bore 19f in front of the bullet and sealed against fluid by a disk 41 pressed into a shallow counterbore at the muzzle end of bore 19f. To explode the charges 40 a longitudinal hole 42

intersecting the bores 19f may be provided and the hole filled with powder which is ignited by an electrical fuze 15f at the upper end. To limit dissipation into the hole 42 of pressure developed in the gun bores 19f, screw plugs 44 having small transverse passages 45 therein may be screwed into tapped holes provided therefor immediately above and below each gun bore 19f, which plugs can be replaced when their passages 45 have been eroded by use.

When the system of Fig. 9 is used, the explosive may be any one of many known types. One that is suitable is a double base pistol powder such as the product of the Hercules Powder Co. known in the trade as " Bull's Eye " brand.

It will be observed from the foregoing description of several forms which the invention may assume, that in each instance the propulsive charge 20 is detonated by the concussion or detonation force of detonation means disposed in front of the bullet, the detonation force of which is transmitted to the propulsive charge by the bullet. This novel firing arrangement possesses several distinct advantages over other known firing arrangements. The gun structure is thereby rendered simpler and less costly to manufacture, since the gun bores are open only at one end and no auxiliary passages are required to afford access to the powder chamber rearwardly of the bullet. Furthermore, the elimination of such other passages simplifies the problem of sealing the powder chamber from the fluid in which the gun is usually immersed when fired.

Another important aspect of this invention relates to the greatly increased propellent effect of the powder charge when detonated in this manner. It has been discovered that certain explosives of the propulsive type, such as that sold under the trade name " Bull's Eye," are in fact what may be termed self-detonating concussion responsive explosives which can be detonated by concussion alone, without the aid of primers or detonation initiators. Furthermore, it has been found that when such an explosive is detonated in this manner its propellent effect is greatly enhanced. This increased propellent effect is of utmost importance in gun perforating of well casing, for obvious reasons. The gun bores of gun perforators are necessarily relatively short, and, in order to impart the necessary muzzle velocity to the bullets, various expedients have heretofore been resorted to, such as the provision of frangible disks or the like to retard movement of the bullets until the pressure developed by the explosion of the propulsive charges reaches a predetermined magnitude. It has been found, however, that by firing in accordance with the present invention a very high muzzle velocity is attained without the use of such retarding devices. It is self-evident that when a retarding device such as a frangible disk is employed, a substantial portion of the energy developed by the explosive is consumed in shearing the disk, and for this reason such devices at least partially defeat their own purpose. The attainment of sufficient muzzle velocity by the manner of detonating the propulsive charge, in contradistinction to the use of retarding devices, is therefore considered to be a great forward step in this art.

Another factor contributing to the increased muzzle velocity is the fact that the pressure wave from the detonation of the explosive charge in front of the bullet is effective to momentarily retard the outward movement of the bullet and thus allow the pressure behind the bullet to rise to a relatively high value before the bullet starts to move forward. The peak of the pressure wave in front of the bullet is reached substantially simultaneously with the initiation of the explosion at the back of the bullet, and, as the pressure behind the bullet increases, the pressure in front of the bullet decreases. The bullet obviously cannot move forwardly until the pressure behind the bullet exceeds that in front of the bullet, and when this condition prevails the pressure behind the bullet has reached a high value. The pressure in front of the bullet decreases very rapidly due to the rapid cooling of the gases by the surrounding liquid, and consequently by the time the bullet has moved a very short distance the pressure wave in front thereof has subsided to substantially the hydrostatic pressure of the liquid.

Still another factor which contributes to increased muzzle velocity and greater penetrating effect of the bullets is the fact that as the bullet moves forwardly the path of the bullet is filled with gas from the detonation of the charge in front of the bullet. Ordinarily, when a gun perforator is fired by known methods, the bullets are projected through a body of liquid, which obviously offers more resistance than a body of gas. Consequently, by the present improved manner of firing there is materially less decrease in velocity of the bullet between its emergence from the gun bore and its contact with the casing.

Although an important phase of this invention relates to the detonation of the

propulsive charge by the rearward concussion transmitted thereto by the bullet from the detonation of an explosive charge in front of the bullet, it will be appreciated that the advantages resulting from this manner of firing are attained even though detonation of the propulsive charge by concussion may be assisted or augmented by the use of priming means. Hence it is to be understood that priming means may be used, if desired, and the terms "propulsive charge" and "explosive means," as used in the appended claims, do not necessarily exclude priming means associated with the powder charge.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A gun perforator, particularly for well casings, comprising a gun body defining a gun bore, a projectile in said gun bore, a concussion-responsive propelling explosive charge in said gun bore rearwardly of said projectile, and concussion-generating explosive means in front of said projectile which on explosion drives the projectile rearwardly in the gun bore, thereby exploding the propelling charge.

2. A gun perforator, particularly for well casings, comprising an elongated gun body defining a number of laterally directed gun bores, a projectile in each of said gun bores, a concussion-responsive propelling explosive charge in each gun bore behind the projectile, and concussion-generating explosive means in front of each projectile, which on explosion drives the projectile rearwardly in the gun bore thereby exploding the propelling charge.

3. A gun perforator according to claim 1 or 2, wherein said concussion-generating explosive means is positioned at least partially within said gun bore in front of said projectile for subjecting said projectile to concussion sufficient to explode said propelling charge.

4. A gun perforator according to claim 1, 2, or 3, including fuze-like detonating means passing along said gun body and traversing the muzzle end of the or each gun bore.

5. A gun perforator according to claims 2 and 4, wherein said gun body structure is provided with an external groove intersecting the muzzle ends of said gun bores and adapted to receive said fuze-like detonation means.

6. A gun perforator, particularly for well casings, comprising a gun body defining a number of laterally directed gun bores angularly disposed with respect to each other, a projectile in each of said gun bores, concussion-responsive propelling explosive means in said gun bores rearwardly of said projectiles, and fuze-like concussion-generating detonation means wrapped helically about said gun body and traversing the muzzle end of each of said gun bores the explosion of explosive means in front of said projectile driving the projectile rearwardly in the gun bore thereby exploding the propelling charge.

7. A gun perforator according to claim 6, wherein said gun body is provided with a helical groove intersecting the muzzle ends of said gun bores and adapted to receive said fuze-like detonation means.

8. A gun perforator, particularly for well casings, comprising a gun body defining a number of laterally directed gun bores, projectiles in said gun bores, concussion-responsive propelling explosive means in said bores rearwardly of said projectiles, concussion-generating detonation means in said bores in front of said projectiles, and common means for detonating all of said detonation means, wherein the explosion of explosive means in front of said projectile drives the projectile rearwardly in the gun bore thereby exploding the propelling charge.

9. A gun perforator according to claim 8, including first detonating means in said bores in front of said projectiles, and fuze-like detonation means passing along said gun body structure in detonating relation to each of said first detonation means.

10. A gun perforator according to claim 9, including a passage within said gun body communicating with each of said gun bores and accommodating said fuze-like means, said first detonation means in each of said gun bores in front of the projectiles being in position to be detonated by said fuze-like means.

11. A well casing perforating gun comprising a body having a number of firing barrels therein, each barrel being adapted to be loaded with a projectile, a concussion-responsive propelling charge between the projectile and the closed rear end of the barrel, and a priming charge between the projectile and the discharge or muzzle end of the barrel, and common igniting means associated with the respective discharge ends of the barrels and adapted to cooperate with the several priming charges in exploding the latter so as to drive the respective projectiles rearwardly, compressing the propelling charges to a point where the latter are exploded so as to drive the projectiles

from the barrels.

12. A perforating gun according to claim 11, wherein said discharge ends of the barrels are arranged in helical formation around the body and the body is provided with a helical groove associated with said discharge ends and adapted to receive said common igniting means.

13. A gun perforator having its parts constructed and adapted to operate substantially as herein described with reference to any of the embodiments illustrated in the accompanying drawings.

Dated the 9th day of October, 1946.

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Fig. 1.

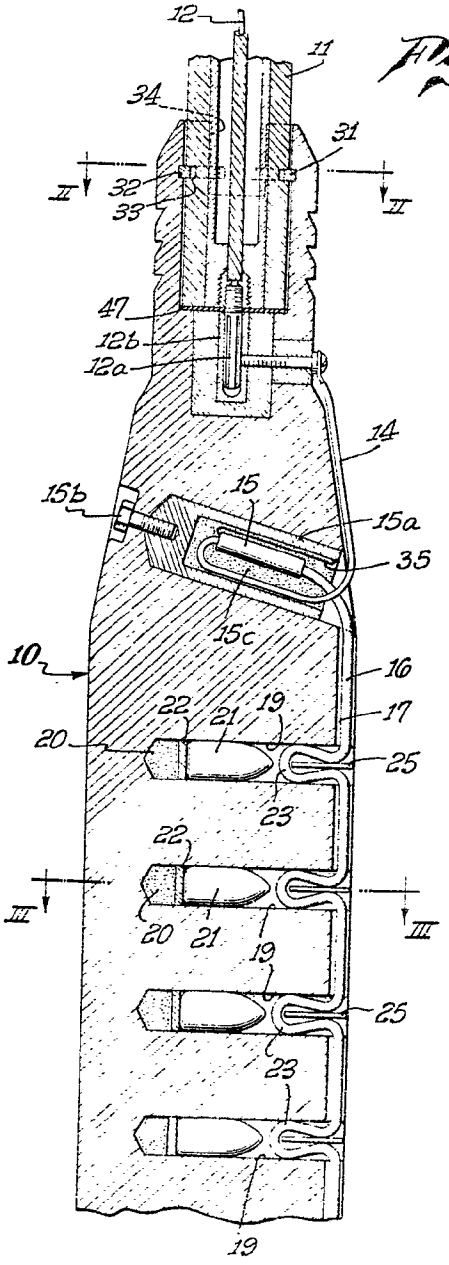


Fig. 2.

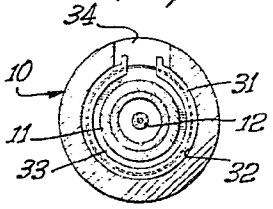


Fig. 3.

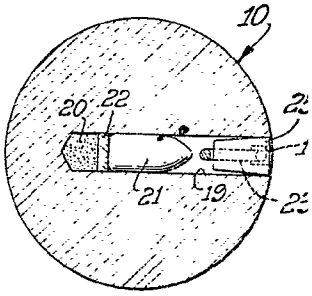


Fig. 2.

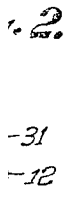
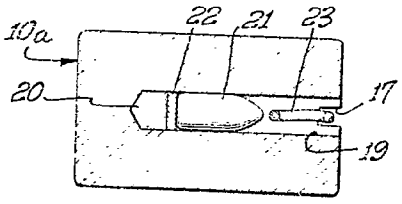


Fig. 3.

Fig. 4.



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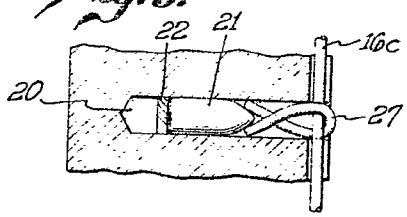

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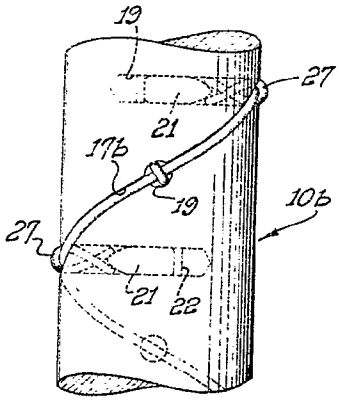

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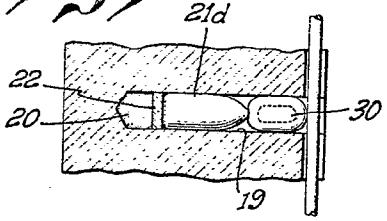


Fig. 8.

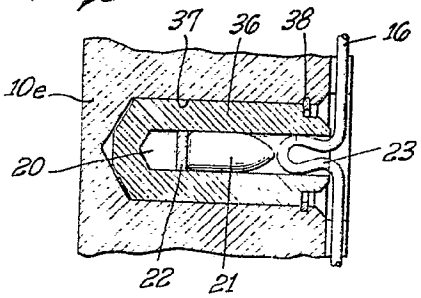
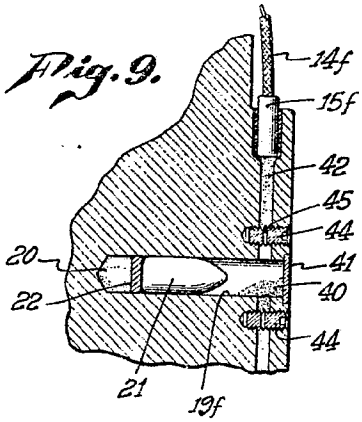


Fig. 9.



H.M.S.O. (Ty. P.)

617,617 COMPLETE SPECIFICATION

SHEET 1

SHEET 2

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Fig. 1.

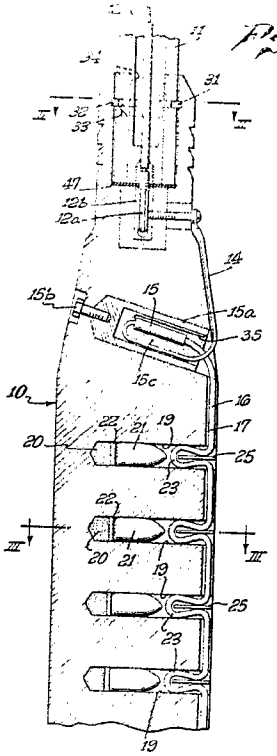
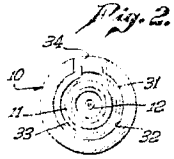


Fig. 2.



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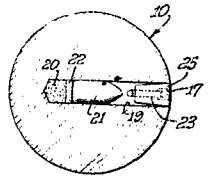
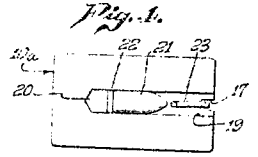


Fig. 4.



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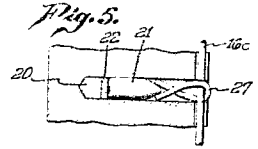

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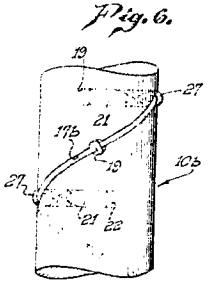

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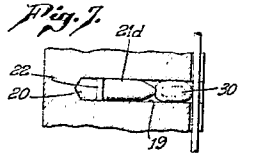

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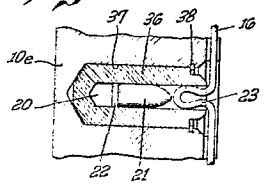

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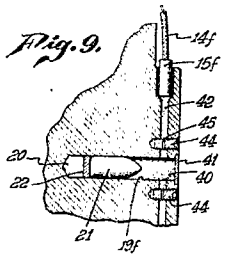

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